W91321-04-C-0023

LOGANEnergy Corp.

McEntire ANGB PEM Demonstration Project
Final Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

McEntire Air National Guard Base
Main Base Fire Station
Columbia, South Carolina

Aug 4, 2006

Executive Summary

Under terms of its FY'03 DOD PEM Demonstration Contract with ERDC/CERL, LOGANEnergy has installed, operated and decommissioned the operation of a Plug Power GenSys5C 5kWe Combined Heat and Power fuel cell power plant at McEntire Air National Guard Base, located near Columbia, SC. During its one year period of performance in CHP configuration operating on natural gas, the project achieved 96% availability.

The McEntire site selected for the one-year demonstration project was the based fire station. The unit was electrically configured to provide grid parallel/grid independent service to the facility, and was thermally integrated with the facility's gas-fired water heater to support laundry thermal loads. Electric power service and natural gas service was provided by South Carolina Electric and Gas. The project added $698.00 in annual energy costs to McEntire during the period of performance.

The McEntire ANGB POC for this project was Lt. Col. Nelson McLeod of the SCANGB Civil Engineering Squadron who provided great support and assistance in achieving the success enjoyed by this project. His contact information is as follows:

Tel: (803) 647-8606

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

LOGANEnergy Corp. Small Scale PEM 2004 Demonstration Project at McEntire ANGB located just outside of Columbia, SC

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation
1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 PAFC, PEM, and Solid Oxide fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P LP Gas unit, and the GenCore 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vinny Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700, ext.1228, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Chris Davis
Title	President	Vice President Operations
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	(860) 872-1120
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	cdavis@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Chris Davis
Title	President	Vice President Operations
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	(860) 872-1120
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	cdavis@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability. LOGAN performs the quarterly and annual service prescribed by the UTC, and performs other maintenance as required. The periods of unavailability are chiefly due to persistent inverter problems that seem to be endemic to the Toshiba power conditioning balance of the system. Field modifications and operating adjustments have largely cured the problem. Quarterly service events take 10 hours to complete with the unit under load, and the annual event takes approximately 35 hours with the unit shut down.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys5C and one 5kWe GenSys5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Vinny Cassala
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1228

LOGAN performed the start-up of both units after Southern Maryland Electric Cooperative completed most of the installation work. The units are located at residential sites at Patuxant River Naval Air Station, MD and operate in standard gird connected/grid independent configurations. Both operate at 4.5kWe and have maintained 98% availability. The units, S/Ns 241 and 242 are two of the very latest GenSys models to reach the field. S/N 242 is Plug Power's first LPG fueled system to go into the field. Both have set new performance standards, and raised expectations for near term commercial viability for this product. Operations to date are indicative of the success of the various test and evaluation programs that have been conducted over the past two years.

c) Contract: A Partners LLC; Commercial PC25 Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.

Mr. Ron Allison
A Partners LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

On April 20, 2004 LOGAN completed the installation of a 600kWe PC25C CHP fuel cell installation in Fresno, CA. The system operating configurations allow for both grid parallel and grid independent energy service. The grid independent system is integrated with a Multi Unit Load Sharing (MULS) electronics package and static switch, which initial development was funded by ERDC CERL in 1999. This is the third fuel cell installation that uses the MULS System. The thermal recovery package installed in the project includes a 100-ton chiller that captures 210 degree F thermal energy supplied by the three fuel cells to support cooling loads on the first three floors of the host facility. The fuel cells also provide low-grade waste heat at 140 degrees F that furnishes thermal energy to 98 water source heat pumps located throughout the 12-story building during the winter months.

7.0 Host Facility Information

McEntire Air National Guard Base (ANGB) is located approximately 16 miles southwest of Columbia, South Carolina. The 2,400-acre base is owned by the US Government and is operated by the South Carolina Air National Guard. McEntire ANGS owns 2,344 acres and leases approximately 64 acres from the State of South Carolina. Additionally, there is a small parcel of privately owned land within the base boundary; however, neither the leased land nor the privately owned land contains utilities.

The South Carolina Air National Guard was formed in December 1946 and today is made up of 1,300 members who train at McEntire ANG Station. The base is home to the 169th Fighter Wing, which flies the F-16 multi-role fighter. An Army National Guard aviation unit is also a tenant on the base.

The base has a total 95 buildings: 90 industrial, 4 administrative and one services totaling 263,000 square feet. There is no family or transient housing. New facilities under construction include an addition to the avionics building (2,500 square feet) and replacement of the air traffic control tower and aircraft support equipment facility (14,600 square feet total). Additionally, seven facilities totaling approximately 21,000 square feet were demolished in FY 2001. There are 550 full-time ANG personnel on base which increases to 1300 one weekend per month. Additionally, there is a small cadre of Army personnel on base, increasing to 400 every other weekend.

McEntire Air National Guard Base is named for the late Brigadier General Bernie B. McEntire, Jr., the first commander of the S.C. Air Guard and its first general officer. General McEntire died in May 1961 when he rode his malfunctioning F-104 into the Susquehanna River to avoid crashing in the populated area of Harrisburg, PA. The base was previously known as Congaree Air Base and was used in World War II as a U.S. Marine Corps training base.

8.0 Fuel Cell Installation

The photos in Figures 1 and 2, below, are pictures of the rear elevation of the fire station at McEntire ANGB, the original site for the PEM project. During the site evaluation performed by Mike Harvell of LOGAN and supported by Lt. Col McLeod on September 15, 2004, the parties agreed that the fire station would provide a good opportunity to install the fuel cell to best effect.

Figure 1 – Rear Elevation of McEntire Fire Station

Figure 2 – Fuel Cell Pad Site

The photo above in Figure 2 shows the Plug Power Gensys5C fuel cell on its pad in a niche formally occupied by a trash dumpster. The unit was delivered on October 15, 2004. Providing gas service for the fuel cell presented a new challenge for LOGAN, since the closest natural gas tie-in is on the roof of the building, some 100 feet from the unit. The safety concerns associated with running a connection to the natural gas line over such a long distance forced LOGAN to reconsider the proposed pad site in hopes of finding a more convenient location.

In Figures 3 and 4, below, the safer, more suitable location for the fuel cell can be seen located much closer to the existing natural gas piping. This pad site is situated behind the McEntire ANGB Fire Station, and while this location does not afford as much visibility as the initial site, greater operational safety and cost effectiveness dictated the change. The yellow piping seen in Figure 3 is natural gas source used by LOGAN to supply the

Figure 3 – Alternative Fuel Cell Pad Site

Figure 4 – Fuel Cell and Electrical Mounting Bracket

Figure 5 – Filtration/Comm. Hardware

fuel cell. Additionally, access to the mechanical room is much closer at this pad site than the former described above. The door to the mechanical room is just to the right of the fuel cell in Figure 3, just a few feet away from the pad site.

From the perspective in Figure 4, it is easy to see the maintenance disconnect panel and accompanying electric meter mounted on the bracket attached to the fuel cell. Inside the mechanical room, located just to the right in Figure 4, LOGAN technicians mounted both the Connected Energy communications hardware and the reverse osmosis water filtration equipment. These components can be seen pictured below in Figure 5.

The building did not originally have commercial high-speed Ethernet service, but the POC was helpful in assisting LOGAN to acquire the service. LOGAN contracted a local wireless ISP to deliver the service to the facility. The installation plan simulates a critical load application by wiring non-critical circuits in the fire station to a newly mounted fuel cell emergency load panel.

9.0 Electrical System

The Plug Power GenSys 5C PEM fuel cell power plant provides both grid parallel and grid independent operating configurations for site power management. This capability is an

important milestone in the development of the GenSys5 as it approaches product commercialization. The unit has a power output of 110/120 VAC at 60 Hz, and when necessary the voltage can be adjusted to 208 VAC or 220 VAC, depending upon actual site conditions. At this site the unit has been connected to the facility in a grid parallel/grid independent configuration, dispatching power at 2.5 kW for most of the period of performance. The photo below in Figure 6 shows the electrical service panel where the fuel cell was electrically coupled to the base utility grid in a spare 50-amp circuit breaker cubicle. The electrical closet is conveniently located behind the exterior wall adjacent to the fuel cell pad site. A separate emergency panel was installed adjacent to this service panel to provide stand-by power from the fuel cell to support several non-critical loads in the event of a grid failure during the test period. This was intended to demonstrate the fuel cell's grid independent capability, however the opportunity never occurred.

Figure 6 – Main Service Panel for McEntire ANGB Fire Station

10.0 Thermal Recovery System

The thermal recovery system installed by LOGAN at McEntire ANGB tested a new heat exchanger technology manufactured by Butler Sun Solutions' Solar Wand. LOGAN opted for this heat product in place of the usual Heliodyne in order to both diversify the GenSys thermal recovery projects and investigate the possible benefits afforded by a different exchanger design. While the Heliodyne has proven highly reliable and efficient in previous GenSys PEM demonstrations, the Solar Wand allowed LOGAN to expand the heat exchanger possibilities for future CHP sites.

The Butler Sun Solutions Solar Wand was designed to allow standard hot water tanks to make use of solar heating, but proved adaptable to this application. The Solar Wand is a double-walled heat exchanger that fits into any full size domestic hot-water tank. The

apparatus screws into the outlet port of a standard hot water tank, providing a new hot water outlet and also fluid input/output connections.

The Solar Wand itself provides approximately two square feet of heat transfer surface inside the tank. The solar collector fluid, in LOGAN's case a mixture of propylene glycol and water, is isolated from the hot water by two copper walls while the space between is vented outside of the tank. The Solar Wand allows the customer to use the existing hot water tank and a single pump to circulate fluid from the fuel cell customer heat exchanger to the Solar Wand.

Hot water tanks with built in heat exchangers are not usually available at water heater retail outlets, which makes this component particularly attractive in this application. Figure 7 below shows the Solar Wand component on its own as well as a close-up of the exchanger installed on a fire station water heater.

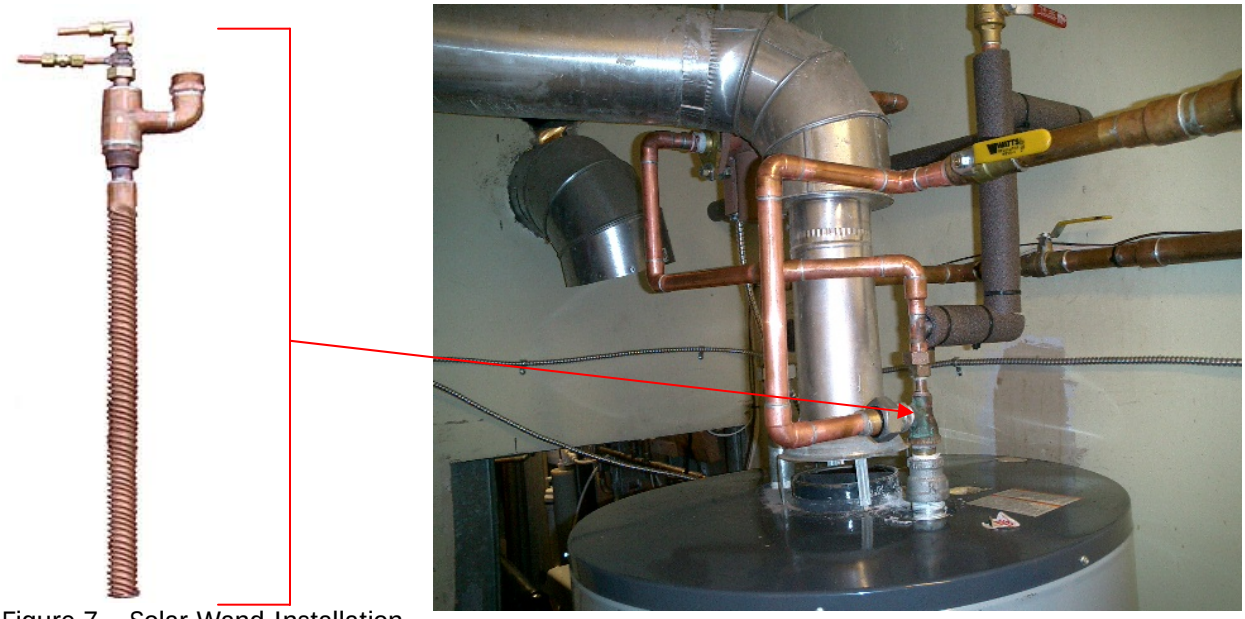


Figure 7 – Solar Wand Installation

11.0 Data Acquisition System

With the help of Nelson McLeod, LOGANEnergy's point of contact at McEntire ANGB, LOGAN installed a Connected Energy Corporation web-based SCADA system that provides high-speed access to real-time monitoring of the power plant. The schematic drawing seen below in Figure 8 describes the architecture of the CEC hardware that supported the project. The system provides a comprehensive data acquisition solution and also incorporates remote control, alarming, notification, and reporting functions. The system picks up and displays a number of fuel cell operating parameters on functional display screens including: kWh, cell stack voltage, water management, as well as external instrumentation inputs including Btuh, fuel flow, and thermal loop temperatures. LOGAN's Operations Control Center in Rochester, New York maintains connectivity by means of a Virtual Private Network that links the fuel cell to the center.

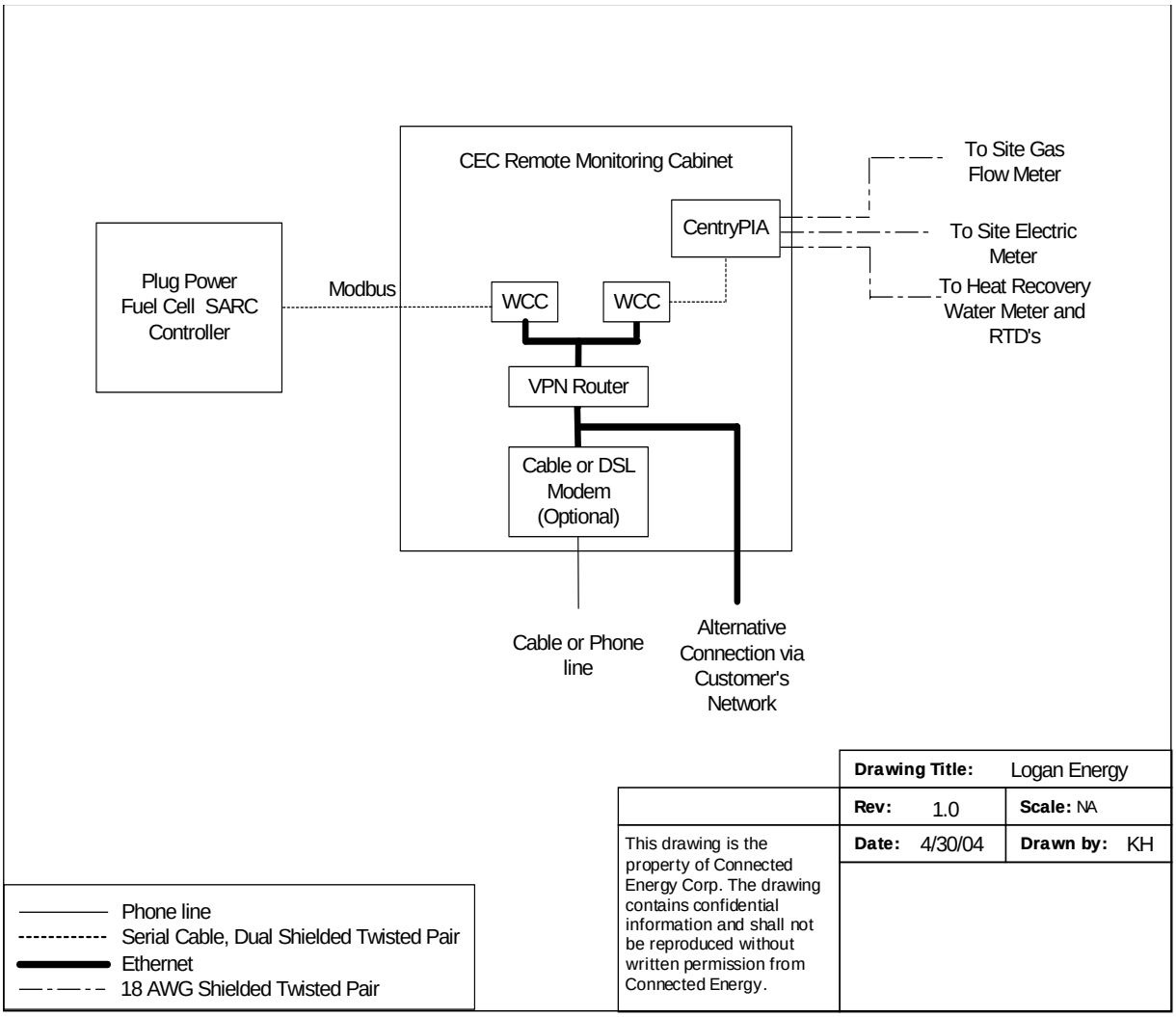


Figure 8 – CEC WEB enabled SCADA Terminal Hardware

LOGAN procured wireless Internet access to the fuel cell router from a service provider. The base provided a local dial tone to a phone jack that is conveniently located in the mechanical room of the McEntire ANGB Fire Station. This provided analog communications with the fuel cell data modem that enabled LOGAN to make some minor adjustments to operating set points and to restart the unit remotely.

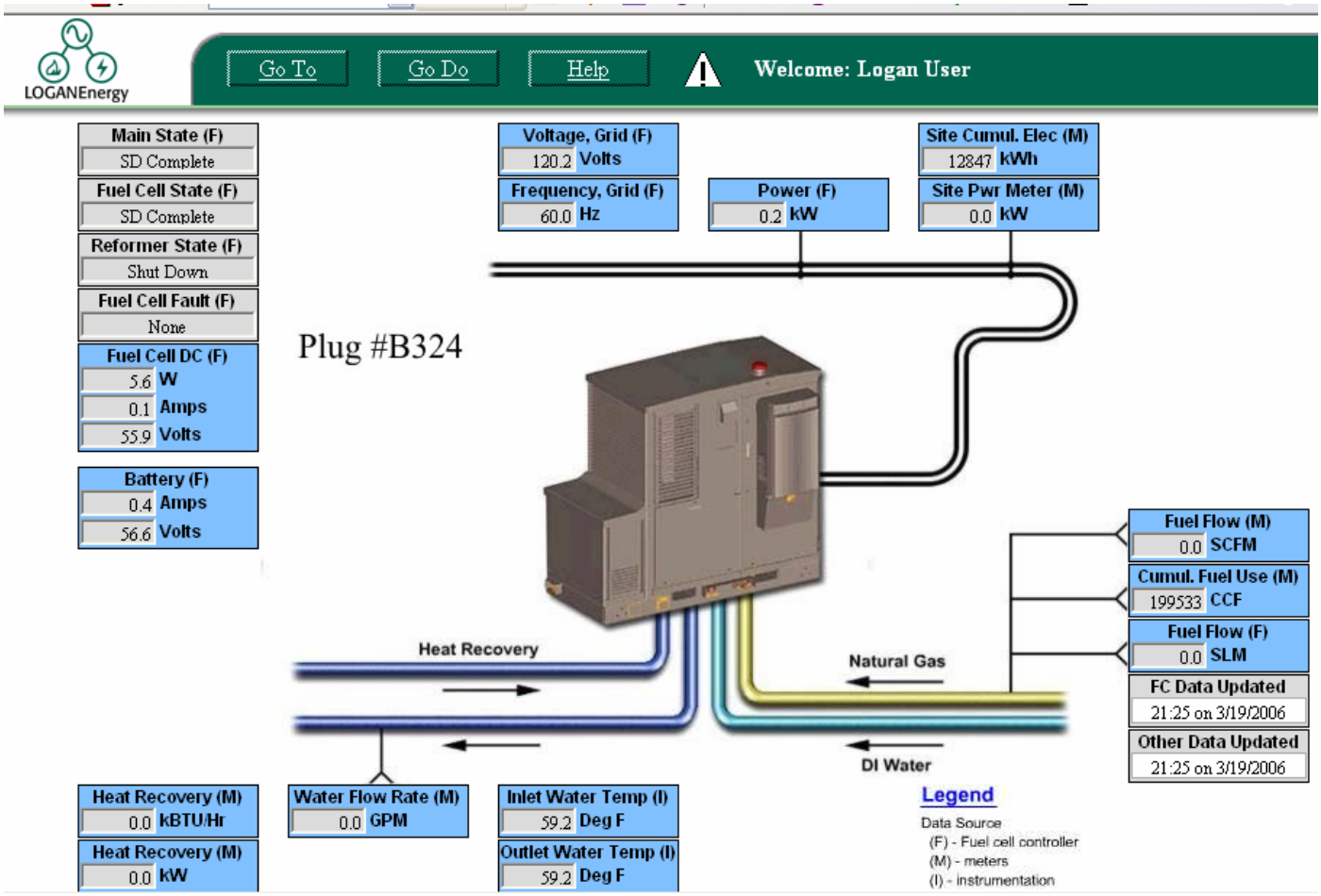


Figure 9, Connected Energy Web Data Screen from 10:45 AM on 5/24/06 showing a number of performance data points for S/N B324, the GenSys serial number of the McEntire ANGB unit.

To view the operation of this unit online, go to:
https://www.enerview.com/EnerView/login.asp
Then login as: logan.user and enter the Password: guest. Select the box labeled McEntire Air Base. Then you may navigate the site or other LOGAN sites using the tool bars or html keys.

12.0 Fuel Supply System

LOGAN connected the fuel cell gas piping into the existing natural gas service line adjacent to the fuel cell pad, and installed a flow meter to calculate fuel cell usage. The connections and corresponding gas lines can be seen pictured in Figures 3 and 4, above. A regulator at the fuel cell gas inlet maintains the correct fuel cell operating pressure at 14 inches water column.

13.0 Program Costs

McEntire ANGB Fire Station

Project Utility Rates		**Utility**
1) Water (per 1,000 gallons)	$12.13	Well water
2) Utility (per KWH)	$0.0500	SCEG
3) Natural Gas (per MCF)	$6.63	SCEG

First Cost	**Estimated**	**Actual**	**Variance**
Plug Power 5 kW GenSys5C	$ 65,000	$ 65,000	$ -
Shipping	$ 1,800	$ 1,060	$ 740
Installation electrical	$ 1,250	$ 924	$ 326
Installation mechanical & thermal	$ 3,200	$ 1,700	$ 1,500
Watt Meter, Instrumentation, Web Package	$ 3,150	$ 2,950	$ 200
Site Prep, labor materials	$ 925	$ 1,125	$ (200)
Technical Supervision/Start-up	$ 8,500	$ 13,860	$ (5,360)
Decommission	$ 1,250	$ 1,250	$ -
Total	**$ 85,075**	**$ 87,869**	$ (2,794)
Assume Five Year Simple Payback	$ 17,015	$ 17,574	$ (559)

Forcast Operating Expenses	Volume	$/Hr	$/ Yr	
Natural Gas MCF/ hr @ 2.5kW	0.03	$ 0.22	$ 1,716.47	
Water Gallons per Year	14,016		$ 170.01	
Total Annual Operating Cost				$ 1,886.49

Economic Summary			
Forcast Annual kWH		19710	
Annual Cost of Operating Power Plant	$	0.096	kWH
Credit Thermal Recovery Rate		($0.010)	kWH
Project Net Operating Cost	$	0.085	kWH
Displaced Utility cost	$	0.050	kWH
Energy Savings (Cost)		($0.035)	kWH
Annual Energy Savings (Cost)		($698.34)	

Explanation of Calculations:

Actual First Cost Total is a *sum* of all the listed first cost components.
Assumed Five Year Simple Payback is the Estimated First Cost Total *divided by* 5 years.

Forecast Operating Expenses:
Natural gas usage in a fuel cell system set at 2.5 kW will consume 0.033 MCF per hour. The cost per hour is 0.033 Mcf per hour *x* the cost of natural gas to the site per MCF at $6.63. The cost per year at $1716.47 is the cost per hour at $0.22 *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

Natural gas fuel cell systems set at 2.5 kW will consume 1.6 gallons of water per hour through the DI panel. The total volume of water consumed at 14,016 gallons per year is 1.6 gph *x* 8760 hours per year. The cost per year at $170.01 is 14,016 gph *x* cost of water to the site at $12.13 per 1000 gallons.
The Total Annual Operating Cost, $1886.49 is the *sum of* the cost per year for the natural gas and the cost per year for the water consumption.

Economic Summary:
The Forecast Annual kWh at 19,710 kWh is the product of the 2.5 kW set point for the fuel cell system *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.
The Annual Cost of Operating the Power Plant at $0.096 per kWH is the Total Annual Operating Cost at $1886.49 *divided by* the forecast annual kWh at 19,710 kWh.

The Credit Annual Thermal Recovery at -$0.010 is 7800 *divided by* 3414. This is then *multiplied by* 0.9 *x* 0.1*x* the cost of electricity at $0.0500 per kWh *x* (-1). As a credit to the cost summary, the value is expressed as a negative number.
The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.
The Displaced Utility Cost is the cost of electricity to McEntire ANGB per kWh.

Energy Savings (cost) equals the Displaced Utility Cost *minus* the Project Net Operating Cost.

Annual Energy Savings (cost) equals the Energy Savings *x* the Forecast Annual kWh.

14.0 Milestones/Improvements

GenSys5C S/N 324 achieved 96% overall availability at McEntire ANGB during this project. The unit incorporated the MP-5 inverter designed by Plug Power to provide both grid parallel/grid synchronous and grid independent/load following capabilities. This capability is an important milestone in the development of the Gensys5 product and for the PEM Program itself, as it is a significant developmental step on the pathway to product commercialization. In this particular project, that capability allowed LOGAN to install an "emergency Load" panel at the host site and transfer several circuits to that panel. These circuits included outdoor lighting and laundry facility loads. In the event of a utility failure (which did not occur during the project) these circuits would have remained energized by the fuel cell. The circuitry and functionality describing this can be seen in Figures 4 and 5 above.
S/N 343 also included the capability to recover waste heat through the addition of a customer heat exchanger added to the unit for that purpose. Fuel cell heat is normally rejected through an air-cooled radiator on the unit, but the introduction of a Solar Wand heat exchanger placed inside the facility's hot water heater allowed LOGAN to supply fuel cell heat to satisfy the host's thermal demands. The system functioned adequately as demonstrated from the results of the thermal use recorded in Figure 16 in the Appendix section. However, LOGAN believes that heat recovery techniques need further refinement. A promising area includes future activities focused on integrating into fuel cell projects small commercial HVAC products that will significantly increase thermal recovery load factors. If successfully integrated into a fuel cell energy package, these products will add value to the fuel cell installation and reduce consumer energy costs for heating and cooling.

15.0 Decommissioning/Removal/Site Restoration

S/N 324 was decommissioned and removed from McEntire ANGB during May 2006. The unit was cannibalized for good parts and then delivered to a local scrap yard.
Following the removal of the unit, LOGAN also removed the emergency electrical panel, deconstructed the thermal recovery system and reconnected the fire station's hot water tank to its original configuration.
At the completion of the process, LOGAN's work was inspected by the POC and the project was deemed terminated by McEntire.

16.0 Additional Research/Analysis

In order to provide remote monitoring and capture real time operating data, LOGAN installed a web based control interface with the unit as described in paragraph 11 above. This system allowed LOGAN to store and retrieve operating and performance data over the life of the project. Some of this data is reproduced in Figures 10 – 13 in Appendix Section 1. The data charts provide interval performance for thermal recovery, electric power generation and system efficiency. The data indicates that S/N 324 operated well within the manufacturer's performance specifications and at 96% availability achieved significantly greater operational reliability than required by CERL's performance specifications.
In addition to the above, LOGAN also performed a series of harmonics tests on the unit under normal operations using an Amprobe HarmonaLink 2 testing device; the results of this testing are presented in Appendix Section 2 below. The data describes two test conditions; a. stand alone grid harmonics, and b. the inverter harmonics in a grid connected configuration at 2.2kW.
The IEEE Standard, 519-1992, that governs the performance of the Plug Power states that

1. Total Voltage Harmonic Distortion at rated inverter output is limited to 5% of fundamental frequency voltage, and
2. Individual Frequency Harmonics Distortion is limited to 3% of fundamental frequency voltage.

Referring to the Charts in Appendix 2, the test results indicate that at the time the measurements were taken, no individual Frequency Harmonic exceeded the IEEE standard of 3%, and that total Voltage Harmonic Distortion at 3.4% was well below the upper IEEE limit of 5%.

17.0 Conclusions/Summary

After nine years of supporting many fuel cell installations at various locations throughout the US, the McEntire site was only LOGAN's fifth project demonstration located within an hour's drive of a field office. As a typical prior example, the Barksdale AFB project was a 5 hour drive and the current Tyndall AFB project is a 7 hour drive. Not only did this accessibility contribute to the high availability of this unit as compared to the earlier more remote projects, it also enhanced technical training and improved the knowledge and skills of the attending engineer. As in the earlier Ft. Jackson project, also located in South Carolina, McEntire's proximity allowed the engineer to visit the site on many occasions to test ideas, validate operating parameters as compared with other units operating in similar configurations, and gain new insight into system performance. As a

result, this site contributed to the rapid expansion the company's fuel cell knowledge base and confidence, but similarly it has contributed valuable data to the PEM Program and to Plug Power engineering as well.

In general terms, the McEntire project did not encounter any major obstacles or other events that patience and cooperation among the stakeholders did not eventually solve. However, gaining access to commercial ISP service in order to activate the web based control system was a difficult and time consuming issue that has proved endemic to DOD installations. In this case a number of security issues and miscommunications caused a delay in data collection early in the project. LOGAN was finally able to engage a wireless ISP service provider and gained valuable experience in supporting wireless data systems. The service proved reliable enough to collect and maintain a good data stream in support of the objectives of the project. The test period concluded with a total 8,444 fuel cell load hours, and achieved overall availability of 96%.

In summary, the lesson learned at this site will have positive implications for future PEM operations and customer services. As these experiences are transferred to future installations they will directly benefit the community of CERL projects and equally enhance the reliability of future Plug Power products. This project elevated the awareness of fuel cell technology at McEntire, educated the South Carolina hydrogen and fuel cell community and advanced the broader objectives of the fuel cell industry toward the ultimate goal of product commercialization.

Appendix Section 1

Performance Data

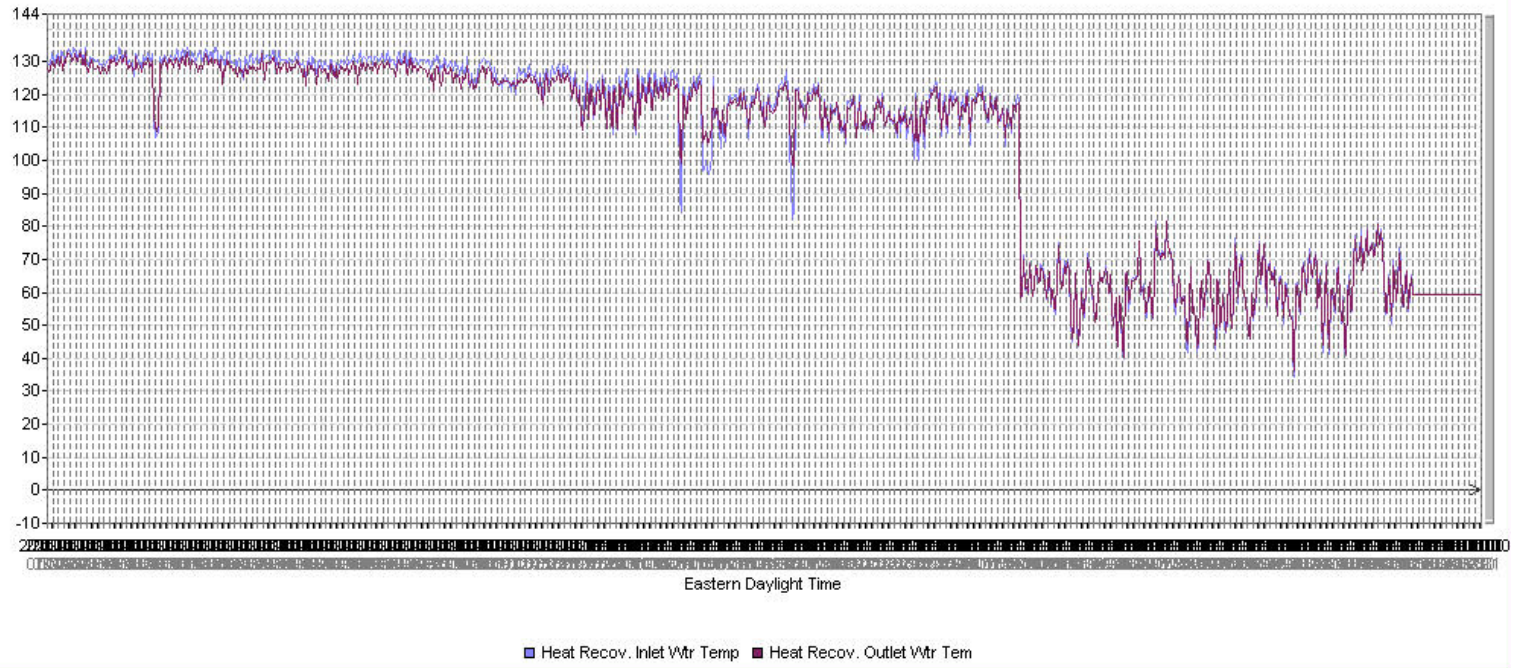


Figure 10, Daily Heat Recovery Temperature Delta from July 23, 2005 through March 20, 2006

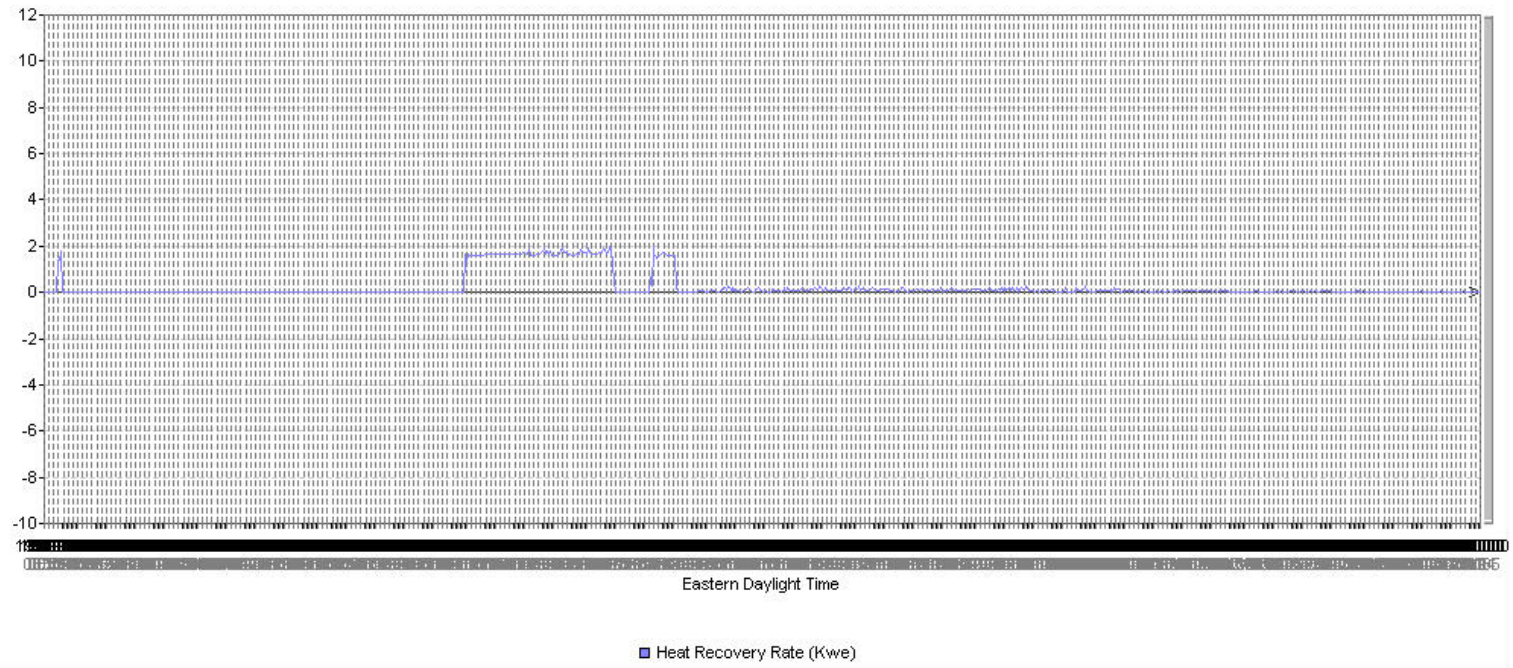


Figure 11, Daily Heat Recovery Rate in KBTU/hr. from March 13, 2005 through January 5, 2006

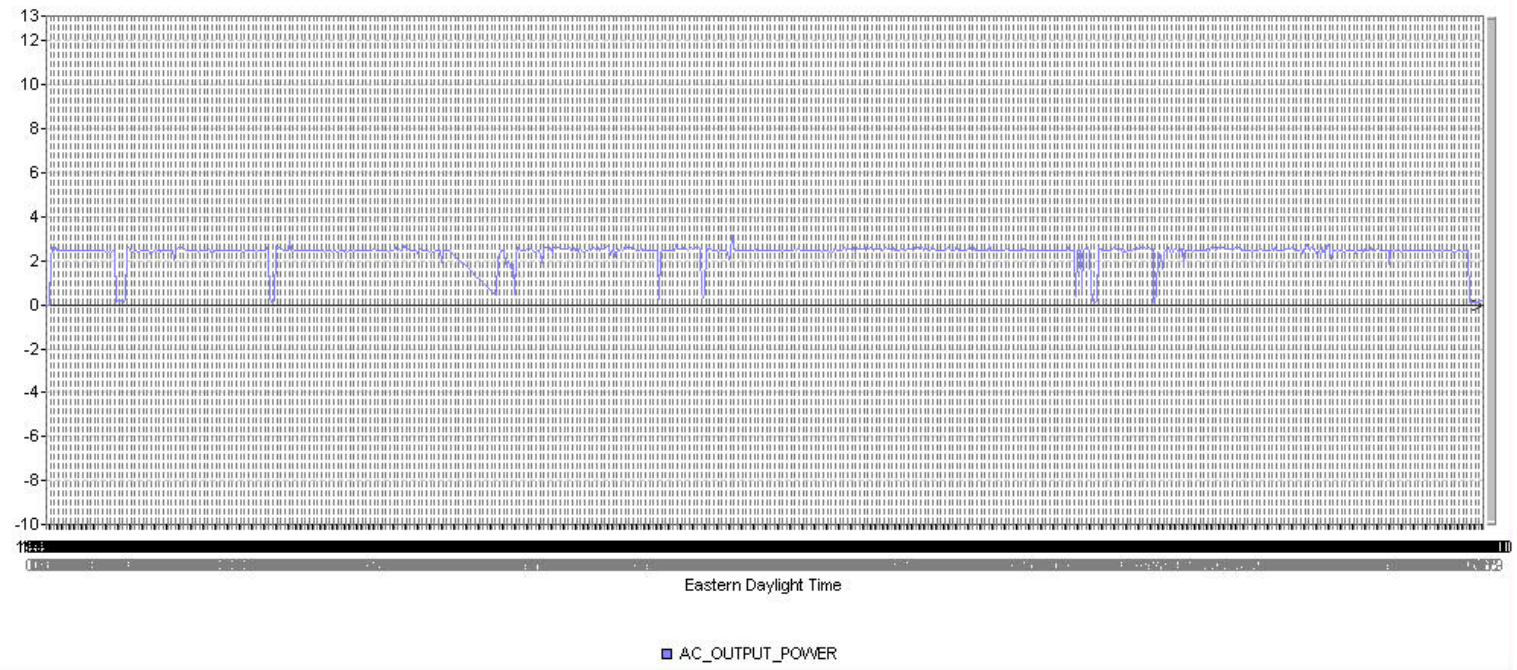


Figure 12, Daily AC Output Power in kW from March 2, 2005 through Feburary 20, 2006

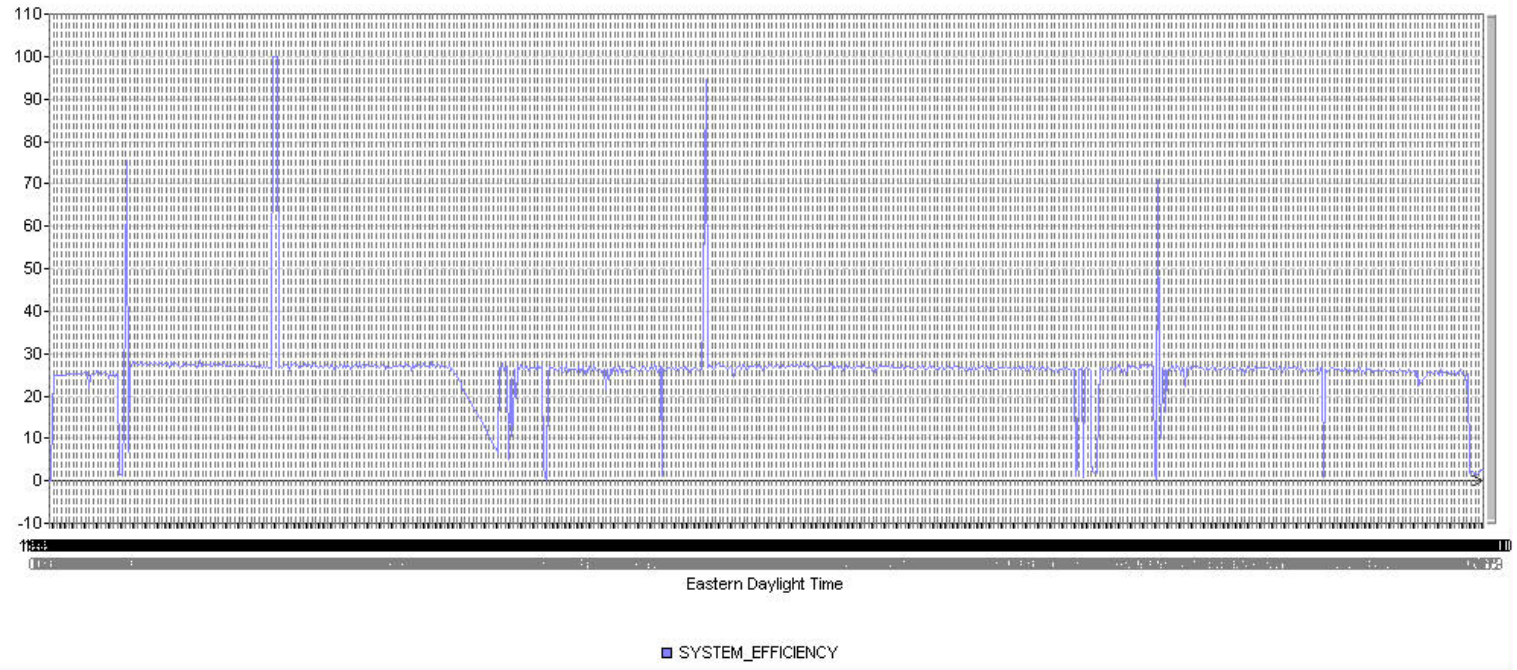
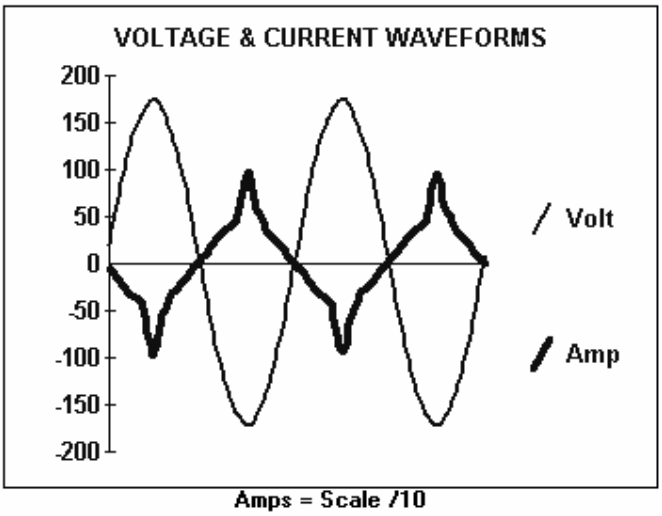
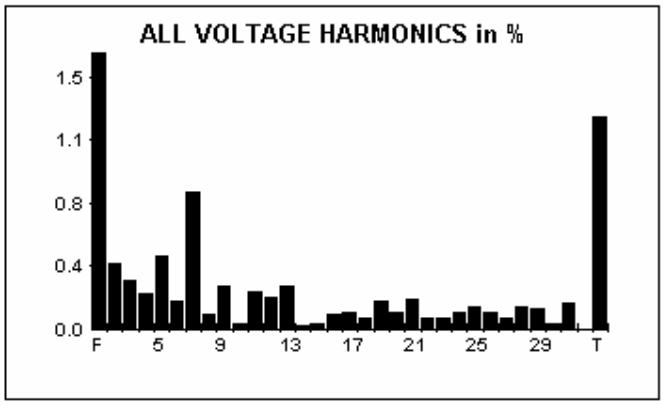


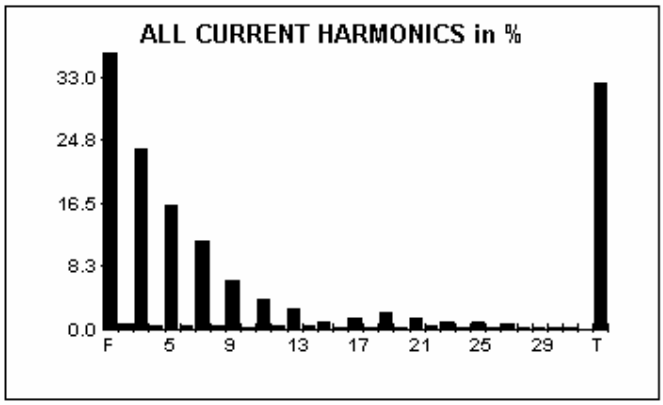
Figure 13, Overall System Efficiency (%) from March 2, 2005 through February 20, 2006

Amprobe HarmonaLink II Power Waveform Analysis



Amps = Scale /10





POWER

Working Pwr	503.36 W
Reactive Pwr	16.56 VAR Lead
Apparent Pwr	528.12 VA
Displacement Pwr	158.94 dVA
True Power Factor	.95 PF
Displacement PF	1.00 dPF

VOLTAGE ODD HARMONICS

H	%	RMS	Angle
1	100.0	121.50	+0
3	0.3	.34	+109
5	0.4	.53	+7
7	0.8	1.00	-172
9	0.3	.31	-98
11	0.2	.27	-123
13	0.3	.31	-116
15	0	0	
17	0	0	
19	0.2	.21	+129
21	0.2	.22	-91
23	0	0	
25	0.1	.16	-4
27	0	0	
29	0.1	.14	+144
31	0.2	.18	+111
Trip.	0.5	.62	
Odd	1.1	1.36	
Even	0.6	.70	
THD	1.3	1.53	

CURRENT ODD HARMONICS

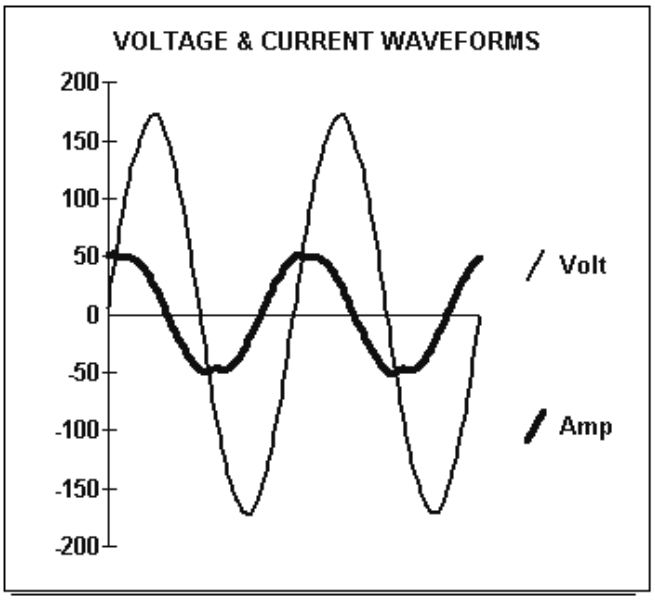
H	%	RMS	Angle
1	100.0	4.14	+0
3	23.7	.98	-173
5	16.2	.67	+17
7	11.6	.48	-148
9	6.2	.26	+58
11	3.9	.16	-96
13	2.7	.11	+94
15	1.0	.04	-125
17	1.5	.06	+41
19	2.2	.09	+178
21	1.3	.05	+30
23	1.0	.04	-133
25	0.9	.04	+118
27	0.6	.02	-40
29	0.2	.01	+160
31	0.2	.01	-174
Trip.	24.6	1.02	
Odd	32.1	1.33	
Even	1.3	.05	
THD	32.16	1.33	

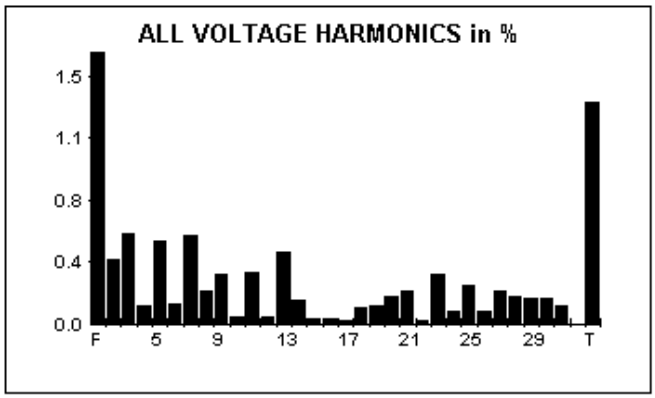
TOTALS	Voltage	Current
Total	121.51	4.35 rms
Peak	172.73	9.81
Avg.	109.34	3.51
DC	.15	.09
Crest	1.42	2.26
Form	1.11	1.24
F Freq	60.04	60.02 Hz
Fund.	121.50	4.14 rms
Harm.	1.53	1.33 rms
THD %	1.26	32.2%
K Fctr	1.02	3.56

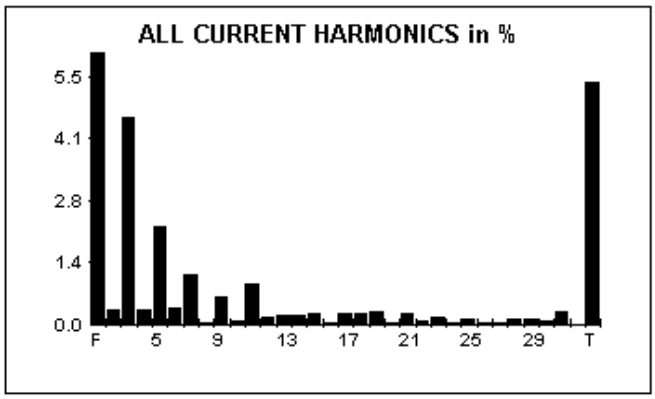
TEST: Phase A on 06-10-05 @ 10:48 AM
Rec: 3,4 In File: C:\AMPROBE\MC2.DAT
Of: Grid Without Fuel Cell
Voltage Ref to: Ground

Figure 14, Utility grid harmonics only.

Amprobe HarmonaLink II Power Waveform Analysis







Working Pwr	2.22 KW
Reactive Pwr	3.92 KVAR Lead
Apparent Pwr	4.52 KVA
Displacement Pwr	232.97 dVA
True Power Factor	.49 PF
Displacement PF	.49 dPF

VOLTAGE ODD HARMONICS

H	%	RMS	Angle
1	100.0	120.73	+0
3	0.5	.65	+88
5	0.5	.61	-23
7	0.5	.65	-173
9	0.3	.36	-132
11	0.3	.38	-169
13	0.4	.52	-141
15	0	0	
17	0	0	
19	0.1	.13	+15
21	0.2	.24	-175
23	0.3	.36	-127
25	0.2	.28	-117
27	0.2	.24	-85
29	0.2	.19	-35
31	0.1	.12	-95
Trip.	0.7	.87	
Odd	1.2	1.47	
Even	0.6	.70	
THD	1.3	1.62	

CURRENT ODD HARMONICS

H	%	RMS	Angle
1	100.0	37.50	+0
3	4.6	1.72	+127
5	2.2	.82	+52
7	1.1	.41	+13
9	0.6	.23	-18
11	0.9	.33	-53
13	0.2	.08	-122
15	0.2	.09	-50
17	0.2	.09	+45
19	0.3	.10	-47
21	0.3	.09	+150
23	0.1	.05	-159
25	0.1	.05	+114
27	0	0	
29	0.1	.04	+103
31	0.3	.10	+109
Trip.	4.7	1.75	
Odd	5.3	2.00	
Even	0.7	.26	
THD	5.38	2.02	

TOTALS	Voltage	Current
Total	120.74	37.56 rms
Peak	171.83	51.81
Avg.	108.64	34.16
DC	.08	.65
Crest	1.42	1.38
Form	1.11	1.10
F Freq	60.02	60.02 Hz
Fund.	120.73	37.50 rms
Harm.	1.62	2.02 rms
THD %	1.34	5.4%
K Fctr	1.03	1.07

TEST: Phase A on 06-10-05 @ 10:37 AM
Rec: 1,2 In File:
C:\AMPROBE\MCENTIRE.DAT
Of: Fuel Cell @ 5kW
Voltage Ref to: Ground

Figure 15, Harmonics with fuel cell operating at 2.22 kW.

Figure 16 Operating Data

McEntire ANGB Fire Station												
Columbia, South Carolina												
	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06
Run Time (Hours)	624	684	744	696	630	696	720	744	654	735	744	377
Time in Period (Hours)	648	720	744	720	744	744	720	744	720	744	744	377
Availability (%)	96%	95%	100%	97%	85%	94%	100%	100%	91%	99%	100%	100%
Energy Produced (kWe-hrs AC)	1642.0	1698.0	1848.0	1695.2	1581.4	1744.0	1817.0	1880.0	1619.0	1882.0	1848.0	933.0
Output Setting (kW)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Average Output (kW)	2.63	2.48	2.48	2.44	2.51	2.51	2.52	2.53	2.48	2.56	2.48	2.47
Capacity Factor (%)	50.68%	47.17%	49.68%	47.09%	42.51%	46.88%	50.47%	50.54%	44.97%	50.59%	49.68%	49.50
Fuel Usage, LHV (kWe-hrs AC)	6506	6283	6887	6670	6540	6549	6818	7102	6200	7062	7183	3730
Fuel Usage, LHV (BTUs)	2.22E+07	2.14E+07	2.35E+07	2.28E+07	2.23E+07	2.23E+07	2.33E+07	2.42E+07	2.12E+07	2.41E+07	2.45E+07	1.27E+07
Fuel Usage (SCF)	21945	21193	23231	22499	22060	22090	22998	23956	20913	23821	24229	12582
Electrical Efficiency (%)	25.25%	27.04%	26.85%	25.43%	24.19%	26.65%	26.67%	26.49%	26.13%	26.67%	25.74%	25.03%
Thermal Heat Recovery (BTUs)	120920	0	0	2882530	1947750	340100	320500	217500	99600	63100	10900	0
Heat Recovery Rate (BTUs/hour)	193.7821	0	0	4141.5661	3091.6667	488.6494	445.1389	292.3387	152.2936	85.8503	14.6505	0
Thermal Efficiency (%)	0.54%	0.00%	0.00%	12.67%	8.73%	1.52%	1.38%	0.90%	0.47%	0.26%	0.04%	0.00%
Overall Efficiency (%)	25.80%	27.04%	26.85%	38.10%	32.92%	28.17%	28.04%	27.38%	26.60%	26.93%	25.79%	25.03%
Number of Scheduled Outages	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled Outage Hours	0	0	0	0	0	0	0	0	0	0	0	0
Number of Unscheduled Outages	1	1	0	1	1	1	0	0	1	1	0	0
Unscheduled Outage Hours	24	36	0	24	114	48	0	0	66	9	0	0

2) Daily Work Logs

LOGANEnergy Field Technicians

September '04 – August '05

LOGANEnergy Corp.					
Monthly Site Report					
Period	September-04				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	9/07/2004	324	Met with Lt. Col. Nelson McLeod to look at three potential sites for the fuel cell.	101	5
Harvell	9/21/2004	324	Met again with McLeod to look more closely at the control tower and fire station	102	5

LOGANEnergy Corp.					
Monthly Site Report					
Period	November-04				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	11/05/04	324	Stack Installed		1

LOGANEnergy Corp.					
Monthly Site Report					
Period	December-04				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	12/05/2005	324	Restarted with no issues, but needed a visit because to reboot controller.	50	4
Harvell	12/29/2004	324	Planning. Purchase of materials. Ordering of materials. Hung DI Panel, pre-filter and iron assy, and Connected Energy box.	296	25

LOGANEnergy Corp.					
Monthly Site Report					
Period	January-05				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	1/11/2005	324			
			RS 232 /Modem Cable Installed		4
			DI Water / Heat Trace Installed		4
Harvell	1/12/2005	324	Natural Gas Pipe Installed		4
Harvell	1/17/2005	324	Arranged for forklift to be delivered. Arranged for trailer to be moved from fuel cell pad area. Shipped old parts back to Plug. Made pad. Moved fuel cell into place. Mounted bracket. Mounted disconnect. Took measurements. Made shopping list. Went to pick up circulation pump and expansion tank. Placed decal on FC. Took pictures and sent them. Picked up misc supplies. Dug trench for pipes. Met with Capt. Noble. Tapped into gas line. Installed gas meter and ran line to fuel cell. Chiseled 3"x8" hole through 13" wall. Ran 1-1/4" conduit, 3/4" conduit, 2 PEX lines to outside of	562	43

			bldg. Installed Istec meter. Covered up trench.		
Harvell	1/25/2005	324	Completed gas line. Completed conduit runs along the outside of bldg, through the wall, and to their termination points. Made several trips to Lowes and Home Depot. Designed, built and hung a new style thermal recovery pump assy that has the fill ports built in. Studied solar wand needs and bought necessary parts.	310	33
Harvell	1/28/2005	324	Met with MSgt. Bledsoe to discuss communication issues 3 times during the week. Hired electrician to terminate wires. Ordered therminol, which was not shipped with fuel cell. Hung CL panel. Completed work on bracket. Pulled wires. Made control and comm. wire terminations in fuel cell and CE box. Installed solar wand and tied into thermal loop. Wired mini-meter. Shopped a lot. Worked with electrician. Partially filled thermal loop. Hunted for 60A breaker. Made stack connections and filled with therminol. Electrician completed most of the wiring.	490	39

LOGANEnergy Corp.					
Monthly Site Report					
Period	Feburary-05				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	2/6/2005	324	DI Panel Drain Installed		1
Harvell	2/14/2005	324		106	20
			2/8/05: Spent time researching and ordering a satellite system that would work for us. 2/9/05: Spent the day cleaning out Yukon, garage, and storage unit of McEntire installation activities. 2/10/05: Went to McEntire to get updates on electrical and phone situation. Completed filling of thermal loop, with much trouble with leaks. 2/11/05: Searched for electrical contractor, to no avail, to finish his work. He seems to have disappeared.		
Harvell	2/25/2005	324			
			Plumbing and Mechanical Connections Inspected for Tightness		0.50
			Stack Coolant Installed		0.50
Harvell	2/26/2005	324			
			Installed Satellite system and got it working. Tried to configure Connected Energy box but could not get my laptop to communicate with the router. Jesse Perkins sent some cables to alleviate the problem. Will fix next week. Met twice with electrician to annoy him into completing his work. He finally did on Friday afternoon. The base communication division surprised me and had the phone line installed at the end of day Friday. I will be going for a start next week.	476	24
			Spent the week trying to get the electrician to complete his 3 hours worth of work. He couldn't find the 60A breaker and was sent somewhere else to work. Had to track down his boss to straighten out their avoidance of completing the work. Continued to press the communication issue (phone line) with the base. Contractors are running the conduit but are not finished. Had to find a place for the satellite dish, which will be installed next week. Things moving slow at this point.		20
Harvell	2/28/2005	324			

			Batteries Installed		0.25
			Wiring Connections Inspected for Loose Connections and Tightness		0.50
			Air Purged from Stack Coolant		0.25
			Radiator Coolant Installed		0.25
			Air Purged from Radiator Coolant		0.25
			Verify Commissioning of DI Water Panel		2
			System Drain Tubing Installed		0.25
			1109618109,2/28/2005 2:15:09 PM,Manual (20)ALERT, PHONE_LINE1_BAD_MODEM_RESPONSE, Error Code: (120)(0)		
			1109618130,2/28/2005 2:15:30 PM,Manual (20)ALERT, PHONE_LINE2_BAD_MODEM_RESPONSE, Error Code: (128)(0)		
			1109618309,2/28/2005 2:18:29 PM,Manual (20)ALERT, PHONE_LINE1_PASSED, Error Code: (115)(0)		
			1109618357,2/28/2005 2:19:17 PM,Manual (20)ALERT, PHONE_LINE2_PASSED, Error Code: (123)(0)		
			1109622280,2/28/2005 3:24:40 PM,ESTOP (107)ESTOP, HW_ESTOP_SARC_L0, Error Code: (534)(0)		

LOGANEnergy Corp.					
Monthly Site Report					
Period	March-05				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
	3/01/2005	324			
			1109690894,3/1/2005 10:28:14 AM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109694894,3/1/2005 11:34:54 AM,Reformer Warmup (32)SHUTDOWN, LEVS5_HUMID_LOW_SD, Error Code: (377)(0)		
			1109694894,3/1/2005 11:34:54 AM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109695006,3/1/2005 11:36:46 AM,Shutdown Complete (105)ALERT, AUTO_RESTART, Error Code: (603)(0)		
			1109695009,3/1/2005 11:36:49 AM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
	3/2/2005	324			
			1109791744,3/2/2005 2:29:04 PM,Unknown (100)ALERT, REMOTE_REQUESTED_SHUTDOWN, Error Code: (600)(0)		
			1109791744,3/2/2005 2:29:04 PM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109792242,3/2/2005 2:37:22 PM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109793858,3/2/2005 3:04:18 PM,Reformer Warmup (32)SHUTDOWN, FS3_REFORMER_AIR_FLOW_LOW_SD, Error Code: (637)(0)		
			1109793858,3/2/2005 3:04:18 PM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		

			1109794032,3/2/2005 3:07:12 PM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109795040,3/2/2005 3:24:00 PM,Reformer Warmup (32)SHUTDOWN, FS3_REFORMER_AIR_FLOW_LOW_SD, Error Code: (637)(0)		
			1109795040,3/2/2005 3:24:00 PM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109796221,3/2/2005 3:43:41 PM,ESTOP (107)ESTOP, HW_ESTOP_SARC_L0, Error Code: (534)(0)		
			1109796708,3/2/2005 3:51:48 PM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109797640,3/2/2005 4:07:20 PM,Reformer Warmup (32)SHUTDOWN, TC10_ATO_1_HIGH_SD, Error Code: (313)(0)		
			1109797640,3/2/2005 4:07:20 PM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109797860,3/2/2005 4:11:00 PM,Manual (20)ALERT, ABORT_DATA_TRANSFER, Error Code: (131)(0)		
			1109798029,3/2/2005 4:13:49 PM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109798208,3/2/2005 4:16:48 PM,Reformer Purge (31)SHUTDOWN, SOL1_FUEL_VALVE_FAILED_CLOSED, Error Code: (623)(0)		
			1109798208,3/2/2005 4:16:48 PM,Unknown (100)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
Harvell	3/8/2005	324	Installed new software update (1.31). Commissioned RO filter. Encountered severe inverter set point loading problems. Repaired leak in glycol side of DI bundle. Charged batteries. Started up on Monday, but had to shut down on Wed. to enable modbus. This caused 4 shutdowns when trying to restart. Worked with Jesse Perkins to get CE box working.	251	22
	3/10/2005	324			
			1110461866,3/10/2005 8:37:46 AM,Running (51)ALERT, TC1_CPO_HIGH_ALERT, Error Code: (257)(0)		
			1110461871,3/10/2005 8:37:51 AM,Running (51)SHUTDOWN, TC10_ATO_1_LOW_SD, Error Code: (310)(0)		
			1110461871,3/10/2005 8:37:51 AM,Unknown (100)SHUTDOWN, TC11_ATO_2_LOW_SD, Error Code: (315)(0)		
			1110461872,3/10/2005 8:37:52 AM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
Harvell	3/14/2005	324	Fuel cell had restarted when I arrived at McEntire. There was an apparent drop in gas pressure that may have caused the high CPO and low ATO temps. This is something I will watch for in the future. I reset the CE box so Mark Ginther could log on.	119	5
	3/19/2005	324			
			1111233941,3/19/2005 7:05:41 AM,Running (51)SHUTDOWN, LEVS5_HUMID_LOW_SD, Error Code: (377)(0)		
			1111233941,3/19/2005 7:05:41 AM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
Harvell	3/21/2005	324	Retraced all wiring to make sure connections were good. Electric meter began pulsing with little more than switching the wires on the terminals. The Istec was another story. After several calls to CE and Istec, it began to pulse, but only for a few hours, then nothing.	310	21

			Another trip on Friday didn't help anything. There is still a pulse issue with the Istec.		
Harvell	3/28/2005	324	Changed particular pre-filter and RO. Both were brown. RO demise was premature.	105	7

LOGANEnergy Corp.					
Monthly Site Report					
Period	April-05				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
	4/2/2005	324			
			1112462522,4/2/2005 12:22:02 PM,Running (51)ALERT, GRID_LOSS, Error Code: (632)(0)		
			1112462522,4/2/2005 12:22:02 PM,Running (51)ALERT, SYSTEM_TRANSITIONED_TO_STANDBY, Error Code: (630)(0)		
			1112462524,4/2/2005 12:22:04 PM,Run-GL-SB (53)ALERT, SYSTEM_TRANSITIONED_TO_GRID, Error Code: (631)(0)		
	4/9/2005	324	1113056443,4/9/2005 10:20:43 AM,Running (51)ALERT, ABORT_DATA_TRANSFER, Error Code: (131)(0)		
	4/10/2005	324			
			1113142843,4/10/2005 10:20:43 AM,Running (51)ALERT, ABORT_DATA_TRANSFER, Error Code: (131)(0)		
			1113170960,4/10/2005 6:09:20 PM,Running (51)ALERT, LOW_CELL_TRIP_ALERT, Error Code: (500)(0)		
	4/11/2005	324	1113229243,4/11/2005 10:20:43 AM,Running (51)ALERT, ABORT_DATA_TRANSFER, Error Code: (131)(0)		
	4/12/2005	324	1113315643,4/12/2005 10:20:43 AM,Running (51)ALERT, ABORT_DATA_TRANSFER, Error Code: (131)(0)		
	4/26/2005	324			
			1114490745,4/26/2005 12:45:45 AM,Running (51)ALERT, FS3_REFORMER_AIR_FLOW_OUT_OF_RANGE, Error Code: (638)(0)		
			1114493710,4/26/2005 1:35:10 AM,Running (51)ALERT, TC1_CPO_HIGH_ALERT, Error Code: (257)(0)		
			1114493862,4/26/2005 1:37:42 AM,Running (51)ALERT, TC2A_CPO_OUT_HIGH_ALERT, Error Code: (267)(0)		
			1114494362,4/26/2005 1:46:02 AM,Running (51)SHUTDOWN, TC1_CPO_HIGH_SD, Error Code: (258)(0)		
			1114494362,4/26/2005 1:46:02 AM,SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1114494477,4/26/2005 1:47:57 AM,Shutdown Complete (105)ALERT, AUTO_RESTART, Error Code: (603)(0)		
			1114494480,4/26/2005 1:48:00 AM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1114509296,4/26/2005 5:54:56 AM,Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1114509475,4/26/2005 5:57:55 AM,Reformer Purge (31)SHUTDOWN, SOL1_FUEL_VALVE_FAILED_CLOSED, Error Code: (623)(0)		
			1114509475,4/26/2005 5:57:55 AM,Unknown (100)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		

LOGANEnergy Corp.					
Monthly Site Report					
Period	June-05				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	6/2/2005	324	Shut down unit for a few minutes to change polisher and restarted. Came up with a plan to modify the thermal loop and began working on it.	201	12

LOGANEnergy Corp.					
Monthly Site Report					
Period	August-05				
Site	McEntire ANGB				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	8/4/2005	324	Swapped out a pre-programmed WCC unit to get the CE box communicating again.	106	5
Harvell	8/11/2005	324	K1 relay was replaced and the new modem.mot revision was added to SARC and tested. The K1 relay was the only component that was replaced, but I believe the fuel cell had been trying to shutdown for the last two months because of a dirty intake screen (Press. 2 issue). I installed a new screen.	208	10